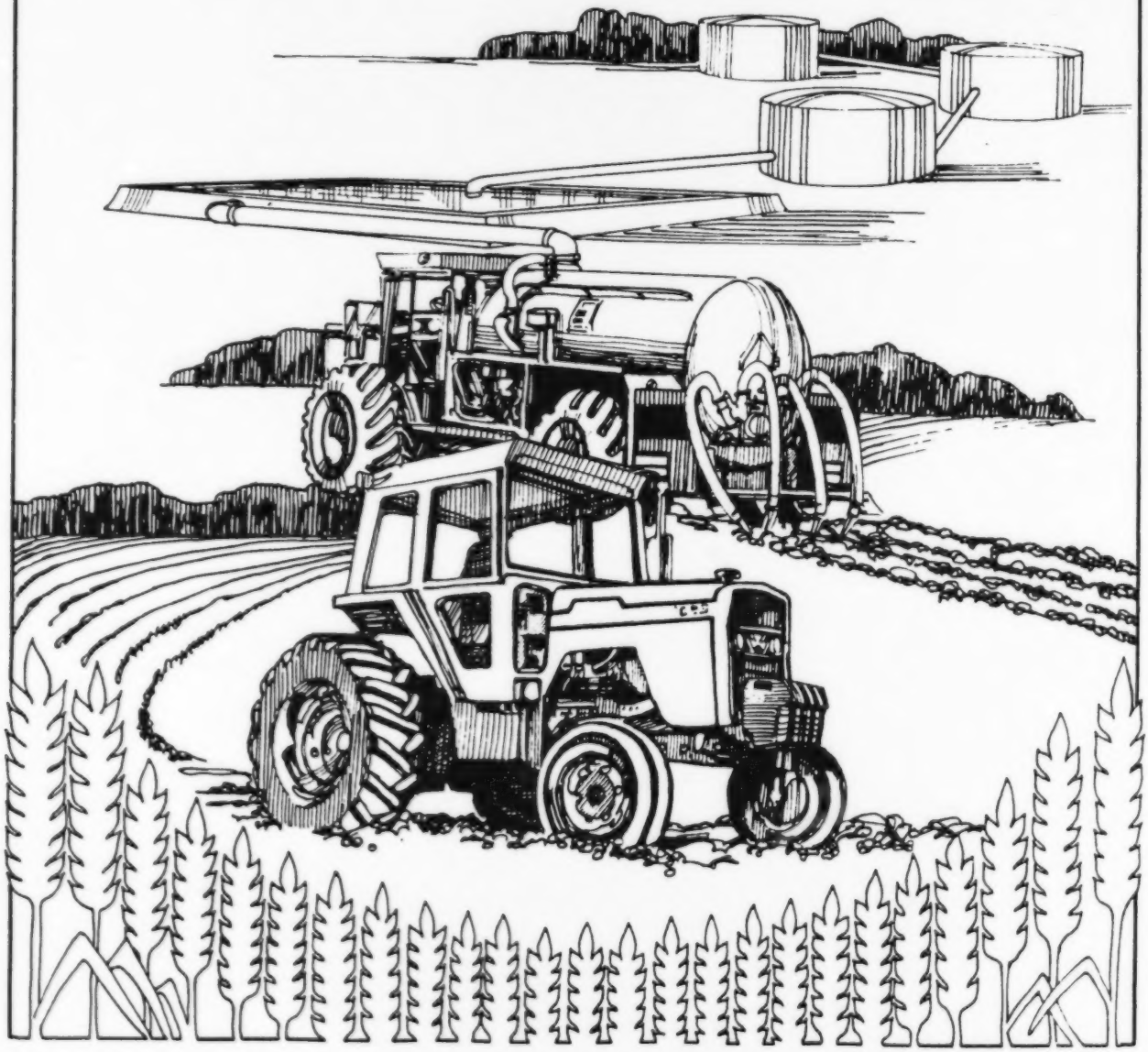
# GUIDELINES FOR THE APPLICATION OF MUNICIPAL WASTEWATER SLUDGES TO AGRICULTURAL LANDS



Alberta
ENVIRONMENT

# Guidelines for the Application of Municipal Wastewater Sludges to Agricultural Lands in Alberta

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# PREFACE

These guidelines are intended for the use of municipalities considering or practising land application as a method of municipal wastewater sludge disposal. The potential hazards and benefits associated with land application of sludge are discussed. Factors which should be considered when planning such a program are specified, and admissible sludge application rates based on these factors are described.

Letters of Permission for land application of sludge will only be issued where local conditions and sludge application rates and practices conform to the philosophy and requirements of these guidelines.

These guidelines only apply to the application of municipal wastewater sludge to agricultural lands. The use of sludge for reclamation of marginal or disturbed lands will be assessed on a site specific basis.

## GENERAL SUMMARY

The application of sewage sludges to agricultural lands can benefit both municipalities and farmers. To municipalities land application is often the most practical method of sludge disposal and to farmers sludge is an excellent potential soil conditioner and fertilizer.

The following table comparing the nutrient content of manures to a typical treated sewage sludge shows that sludge is an excellent source of both nitrogen and phosphorus.

### TABLE

Nutrient Content of Manures and a Typical Sewage Sludge

| MATERIAL | NITROGEN AS N | PHOSPHORUS AS P | POTASSIUM AS K |
|---|---|---|---|
| Chicken Manure | 4.1% | 1.6% (3.7% as $P_2O_5$) | 1.9% (2.3% as $K_2O$) |
| Average Farm Manure | 1.2% | 0.26% (0.6% as $P_2O_5$) | 4.6% (5.5% as $K_2O$) |
| Sewage Sludge* | 4.0% (1.5% inorganic + 2.5% organic) | 1.4% (3.2% as $P_2O_5$) | 0.3% (0.4% as $K_2O$) |

* a digested sludge which has been stored in lagoons

Sludge, on a dry weight basis, also contains approximately 50% organic matter and can therefore improve the tilth and water holding capacity of soils.

Potential problems associated with land application of sludges are odours, public health and veterinary hazards due to pathogenic organisms, surface and groundwater pollution and accumulation of toxic elements and substances such as cadmium, copper, molybdenum, nickel and zinc in soils and crops.

The purpose of these guidelines is to ensure that land application of sludge practices are agriculturally beneficial and environmentally acceptable. The criteria in the guidelines are based on experimental data collected by Alberta Environment, on standards and requirements specified in other Provinces and countries, and on relevant published technical information.

The guidelines contain criteria for establishing both the suitability of a sludge for land application and the acceptability of a site to receive sludge. Site acceptability is determined by examining soil pH and texture, topography, groundwater depths and types of crops to be grown. Sludge suitability for land application is based on a comparison of the nutrient content of the sludge in relation to levels of boron and certain metals. The intent of this method of determining sludge suitability is to ensure that agricultural lands benefit from the addition of sludges through nutrient additions and do not become dumping sites for undesirable elements and substances.

Where sites and sludges are suitable, specific sludge application rates must be established. The allowable sludge application rates specified in the guidelines are based on:

(i) the type of treatment the sludge has received at the municipal sewage treatment plant;
(ii) the amount of nitrogen in the sludge;
(iii) the amount of certain elements in the sludge; and
(iv) the characteristics of the site to which sludge is to be applied.

As well as outlining allowable sludge application rates, the guidelines also have criteria pertaining to set-backs from specified features, suitable times of year for application and return periods for re-application.

Nitrogen and phosphorus additions to soil from a single application of sludge could be as high as

(i) 900 kg/ha (800 lbs/acre) of total nitrogen as N,

(ii) 450 kg/ha (400 lbs/acre) of ammonium nitrogen as N,

(iii) 500 kg/ha (440 lbs/acre) of phosphorus as P (1150 kg/ha (1025 lbs/acre) of phosphorus as $P_2O_5$),

based on the criteria contained in the guidelines, and the use of commercial fertilizers on sludge applied lands are generally not required for at least two years following sludge application. It is recommended that the first commercial fertilizer addition to a parcel of land, following sludge application, be based on soil fertility test results. To minimize the loss of the nutrients from sludges which are surface applied, tillage as soon as is possible after application is required.

One observed problem associated with land application of sludge relates to weed control. Sludge itself is not a significant source of weeds but the fertilization of land through sludge application can produce an excellent environment for weeds as well as crops. Where weeds are, or may be, a problem, it is recommended that a rigorous weed control program be implemented by farmers in conjunction with any land application of sludge.

The guidelines specify the types of crops which should and should not be grown on sludge applied lands (see Table 6). If farmers anticipate that their land may in the near future be used for production of root crops, growing tobacco, production of crops eaten raw, or dairy farm pasturing, it is recommended that sludge not be applied to these fields.

To ensure that sludge is applied to land in an environmentally and agriculturally acceptable manner, communities must obtain an approval from Alberta Environment for any land application of sludge project (see Appendix III). This approval requires that permission be obtained from landowners prior to sludge application to their lands. Landowners should in no way feel obliged to accept sludge from a community and any questions or concerns they may have regarding land application of sludge should be directed to Alberta Environment at the address given in Appendix III of the guidelines.

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# INTRODUCTION

The major goal of municipal wastewater treatment is to produce a liquid effluent which is suitable for discharge to the environment. To achieve this goal, a variety of physical, chemical and biological processes can be employed. While these processes produce a treated wastewater they also result in the production of a residue commonly referred to as sludge.

Principally organic in nature, municipal sludges also contain varying quantities of metals, nutrients, salts, grit, synthetic organics and pathogenic organisms. The exact composition of sludge is a function of the wastewater being treated and can vary significantly from municipality to municipality depending on the quantity and quality of industrial, commercial and institutional inputs. The quantity, quality and characteristics of sludges from wastewater treatment may be altered by employing sludge treatment techniques.

In general, as treatment efficiency increases the volume of sludge increases. Urbanization and more intensive and efficient wastewater treatment systems are resulting in the production of ever increasing quantities of sludge for disposal. The generation, treatment and final disposal of sludge accounts for a substantial portion of the total wastewater treatment costs. Sludge must be disposed of in an environmentally acceptable manner if wastewater treatment, as a whole, is to be considered effective. Commonly employed sludge disposal methods include:

(i) ocean dumping;

(ii) sanitary landfilling;

(iii) incineration;

(iv) permanent lagoon storage; and

(v) land application.

Of these disposal methods, the only way of re-utilizing and conserving the useful constituents in sludge is through its application to land as a fertilizer (Mathews, 1980). This method is also consistent with the objective of disposing of sludge in an environmentally acceptable manner.

The purpose of these guidelines is to:

(i) discuss the risks and benefits associated with the use of sludge on agricultural land;

(ii) provide information on the quantity and quality of sludges generated in Alberta; and

(iii) outline sludge application rates and procedures that should be used when applying sludge to agricultural land in Alberta.

The nutrient and organic content of sludges makes them an excellent potential soil conditioner and fertilizer. Sludges may also contain pathogenic organisms and quantities of elements and chemicals which can adversely affect crop quality and yield and result in pollution of surface and groundwaters. These guidelines represent an attempt to provide criteria which will maximize the benefits associated with land application of sludge while minimizing the potential risks.

An application form for permission to apply sludge to land in Alberta is included in Appendix III.

## POTENTIAL BENEFITS OF LAND APPLICATION OF SLUDGES

Municipal sewage sludges contain most, if not all, of the elements required by plants and, being substantially organic by nature, they are a source of organic matter when added to soil (Hinsely and Sosewitz, 1969; King and Morris, 1973; Milne and Graveland, 1973; Dowdy and Larson, 1975a, 1975b). Many sludge-borne nutrients are organically or inorganically bound and are released gradually in plant-available forms by soil processes. This is particularly important in the case of sludge-borne organic nitrogen, which may be converted to ammonium and nitrate over several growing seasons. The economic value of sludge varies widely with nutrient concentrations. Graveland and McCoy (1979) estimated that the average dollar value of sludge-borne nitrogen, phosphorus and potassium in the Oldman River Basin was approximately $70/t (tonne) of dry sludge. The City of Edmonton (1979) estimated that its sludge had a dollar value of approximately $40/t based on its nitrogen and phosphorus content.

The benefits associated with land application of sludge must also be assessed in relationship to alternative disposal methods. Disposal of sludge must be to the air, land or water. Incineration of sludge is energy intensive, presents potential air pollution problems and produces an ash that requires disposal. Discharge of sludge to fresh or salt water can result in water pollution problems and may adversely affect the food chain. Sanitary landfilling or permanent lagoon storage concentrates sludge solids, metals and nutrients in a confined space with the potential to produce concentrated leachate and the associated risk of groundwater contamination. Storage in permanent lagoons does, however, provide for the potential recovery of nutrients at a later date.

Soil in many respects represents the most suitable disposal medium for sludge; however, an effective management approach to land application of this waste is required.

## POTENTIAL HAZARDS OF LAND APPLICATION OF SLUDGES

### (A) Biological

Potential human pathogens of concern found in domestic wastewaters may be grouped into four categories (Englebrecht, 1978; Parsons et al, 1975):

(1) Bacteria *(Salmonella, Shigella, Mycobacterium, Klebsiella, Clostridium)*;

(2) Protozoan parasites *(Entamoeba, Giardia, Trichomonas)*;

(3) Helminth parasites *(Ascaris, Toxacara, Taenia, Trichuris, Enterobius)*; and

(4) Viruses (Picornaviruses, Adenoviruses, Rotaviruses).

The types and numbers of pathogenic organisms in sludge is a function of the nature of the wastewater being treated, the type of wastewater treatment and the type of sludge treatment. Wastewater organisms such as bacteria and viruses that are adsorbed to particulate matter tend to co-precipitate during settling phases of sewage treatment and are thereby partly removed, as solids, from the water phase (Moore et al, 1975). Similarly, encysted and egg stages of parasites, with specific gravities 1.06 to 1.2 (Englebrecht, 1978), also become concentrated to the sludge phase. Consequently populations of potential human pathogens in sludges are many times greater than that in the source wastewater (Fenger, 1973).

Treatment of sludges by either aerobic or anaerobic digestion markedly reduces, but does not eliminate, most potential human pathogens (Kenner, 1972). Consequently, land spreading of undigested sludge is not recommended by some regulatory agencies (EPA 430/9-77-004; Webber, 1975; Keeney et al, 1975; DeMichele, 1978).

Anaerobic digestion is a process commonly employed to reduce and stabilize the biodegradable organic material in sludges. Conditions within anaerobic digesters are unfavorable, but not lethal, for the multiplication and survival of most pathogenic organisms (Kenner, 1971). Natural die-off of organisms in anaerobic digesters has been directly linked to factors such as digester temperature, microbial predation and competition, adsorption-inactivation by solids, oxygen stress and solids retention time.

Certain pathogenic organisms by virtue of unique, inherent physiological properties possess a greater potential to survive anaerobic sludge digestion (Dudley et al, 1980). *Klebsiella* (capsule formation), *Mycobacterium* (lipid-rich cell wall), *Ascaris* and *Toxacara* (egg stages) and viruses appear particularly resistant to destruction.

Complete destruction of organisms is expected with anaerobic digestion at thermophilic temperatures (60°C) (Water Pollution Control Federation, 1972; Sopper and Kardos, 1973). At temperatures of 55°C to 60°C, thermal death has been observed for most bacteria (Cruickschank, 1965) and parasites (Wiley, 1962). Viruses appear considerably more resistant to destruction, with seeding experiments

showing virus survivals at thermophilic temperatures even after retention times of 50 to 60 days (Engelbrecht, 1978).

Conventional anaerobic digesters operate at mesophilic temperatures (30°C to 38°C) with retention times of approximately 30 days. However, the operation of anaerobic digestors at thermophilic temperatures (45°C to 55°C) is possible (Fair et al, 1968) and may be one method of destroying the pathogenic organisms in sludge.

There are a number of processes specifically designed to destroy pathogenic organisms in sludges. These include (Metcalfe & Eddy, 1978):

(1) pasteurization;
(2) low pressure oxidation;
(3) high pH treatment;
(4) long-term storage;
(5) complete composting at high temperature (greater than 55°C);
(6) chemical disinfection; and
(7) high-energy radiation disinfection.

The need for, and type of, sludge disinfection is generally a function of the nature of sludge, the method of sludge handling and treatment, and the ultimate use of the sludge.

Aerobic digestion is an alternative method of stabilizing the biodegradable material in sludges. Aerobic digestion is primarily used in small sewage treatment plants and has been reported to reduce the number of pathogenic organisms to low levels (EPA 625/1-74-006).

The practise of land application of sludge presents two immediate areas of concern regarding possible associated health risks:

(1) survival of various infectious agents in soil resulting in contamination of forage and edible crops; and

(2) contamination of water as a result of runoff and percolation.

Comprehensive literature reviews on the survival of infectious agents in soil have indicated that under variable inactivation factors (climate, soil type, soil moisture, soil temperature, vegetation, soil pH, soil organic matter concentration, and soil microbial antagonism and competition), the viability of different pathogens may be as short as a few hours or as long as several months (Rudolfs et al, 1950; Gerba et al, 1975) (Table 1). Bare soil surface temperatures approaching 50°C during the summer months were judged instrumental in promoting die-off of parasites introduced to land by sludge application (Graham, 1979). Ultra-violet radiation and dessication were other important mechanisms of pathogen inactivation (Bell, 1976; Bell and Bole, 1976, 1978).

Virus and bacteria movement in soils have been related directly to the hydraulic infiltration rate and inversely to media particle diameter (Gerba et al, 1975; Damgaard-Larsen et al, 1977; Hagedorn, 1978). Other parameters affecting micro-

organism movement in soils included inactivation factors (oxygen tension, temperature, and microbial antagonism and competition), and adsorption factors (soil pH, multivalent cation concentration, and clay content. In the absence of fractures and channelling, upper horizons of the soil appeared efficient in removing most pathogens (Bell and Bole, 1978; Cram, 1943; Akin, 1971). Should pathogens become concentrated in upper soil horizons, however, the possibility of contamination of crops by contact with soil exists (Bell and Bole, 1978).

While limits cannot be set on the number of species of pathogenic organisms that can be applied to agricultural land in sludge, it is necessary to appreciate that a potential health hazard does exist. On the evidence to date, compliance to measures such as proper site selection; proper sludge handling and application; proper crop selection; and selective land use will reduce health risks to a very low level.

## TABLE 1

Survival Times of Various Pathogens in Soil and on Plants

(taken from Englebrecht (1978))

| ORGANISM | MEDIUM | SURVIVAL TIME |
|---|---|---|
| Coliforms | Soil | 30 days |
| | Tomatoes | 35 days |
| *Salmonella typhosa* | Soil | 2-85 days |
| | Vegetables | 7-53 days |
| *Shigella* | Tomatoes | 2-7 days |
| *Vibrio cholerae* | Spinach, Lettuce | 22-23 days |
| | Nonacid Vegetable | 2 days |
| Tubercle bacilli | Soil | Up to 2 years |
| | Radish | 3 months |
| *Entamoeba histolytica* | Vegetables | 3 days |
| | Soil | 8 days |
| *Ascaris* ova | Soil | Up to 7 years |
| | Vegetables | 27-35 days |
| Poliovirus | Soil | 100 days |
| | Radish, Lettuce | 35 days |

## (B) Heavy Metals and Other Elements

Application of sludges to soil enhances the potential for increasing essential and non-essential elements in the food chain (Jones et al, 1973; Page, 1976; Bingham et al, 1976). Increasing the levels of some elements in Alberta cereal grains and forages may be beneficial as levels of some physiologically-essential elements (copper, manganese, zinc) are at or near deficiency levels (Dudas and Pawluk, 1977; Alberta Environment -file data). Increasing the levels of non-essential elements, however, is not beneficial and may constitute a hazard. Heavy or repeated applications of sludges have been reported to cause both phytotoxicity (Patterson, 1971) and deterioration of soil quality by increasing salinity (Epstein et al, 1976). Alberta sludges have been found to be non-saline and do not pose a salinity hazard when applied at recommended rates.

Heavy metal uptake by plants is apparently influenced by many soil properties including pH, organic matter content and cation exchange capacity (Page, 1976; Dowdy and Larson, 1975a; John and van Laerhoven, 1976). In addition, plant species and varieties vary in their tendency to accumulate heavy metals (Dowdy and Larson, 1975a, 1975b) and metals tend to be unevenly distributed within plants (Dowdy et al, 1976; John and van Laerhoven, 1976). Lettuce, spinach, tobacco and chard have been identified as plants which have a tendency to accumulate some heavy metals (Dowdy and Larson 1975a, 1975b; EPA 430/9-77-004); many root crops, forage crops and cereal grains have a relatively low affinity for metal uptake.

Elements have been classified into two groups in terms of their potential hazards to plants and animals when added to the soil in sewage sludges (EPA 430/9-76-013). Manganese, iron, aluminum, chromium, arsenic, selenium, antimony, lead and mercury are classed as "posing relatively little hazard". Several of these, notably aluminum, iron, manganese and trivalent chromium (the dominant form in anaerobic sludges) tend to be present in sludges in relatively large quantities ranging from less than 0.5% to greater than 1% but pose relatively little hazard because they form stable organic or inorganic complexes, sparingly soluble oxides and hydroxides or carbonates, particularly in alkaline soils having a high organic and inorganic collodial content. Recent work (Bartlett and James, 1979) suggests that greater caution should be observed regarding trivalent chromium, especially in soils containing oxidized manganese. Antimony, arsenic, mercury and selenium are usually present in sludges in quantities insufficient to present a serious hazard at sludge application rates designed to meet the nitrogen requirement of crops.

Elements which do pose a significant hazard have been identified as cadmium, copper, molybdenum, nickel and zinc (EPA 430/9-76-013). Of these, cadmium appears to present the major hazard and usually receives special consideration in guidelines on sludge application to land (Keeney et al, 1975; Illinois Environmental Protection Agency; EPA 430/9-77-004; EPA 430/9-76-013; Loftus and Wetter, 1979).

The chemical composition of sewage sludges varies widely, both from one location to another, and with time, from a given location (Sommers et al, 1976; Dowdy et al, 1976). Some data is available on the existing and projected quantities and elemental composition of Alberta sludges (Appendices I and II) and the potential metal uptake by crops on sludge-treated, Alberta soils (Dudas and Pawluk, 1975; McCoy, 1977).

Dudas and Pawluk (1975), using Edmonton sludge and addition rates of 80 and 160 t/ha, found an increase in the uptake of cadmium, copper and zinc by lettuce leaves in a greenhouse experiment. McCoy (1977), using Lethbridge sludge at addition rates of 35 to 60 t/ha, found a small, but significant, increase in the zinc and phosphorus content of alfalfa grown on a Brown Solonetz soil at Enchant. Plant levels of other metals (copper, manganese, iron, lead, nickel or cadmium) were not affected by sludge additions. In another experiment McCoy (1977) found that the metal content (zinc, copper, manganese, iron, lead, nickel and cadmium) of barley grains and straw, grown on a Calcareous Chernozen treated with Calgary sludge at rates up to 22 t/ha were, with one exception (lead content of straw), unaltered by sludge addition. Slight but significant increases in lead contents of straw were detected.

### (C) Other Aspects

Sludges pose a potential hazard to surface and groundwater quality. Nitrate ions, being mobile in the soil system, are of particular concern. "Luxury consumption" of nitrate by plants grown on sludge-treated soils is an additional concern. Application of sludge with 4% of TKN (total Kjeldahl nitrogen) and 2% $NH_4$ – N at rates greater than 40 t/ha resulted in toxic levels of nitrates in barley straw (Alberta Environment -file data). Concern has been expressed that boron levels in sludge may be sufficient to cause plant toxicity or reduce the yield of boron sensitive crops. Preliminary data (Appendix I) of plant available boron levels in Alberta sludge indicates that this is unlikely, but this aspect warrants further study.

# GUIDELINES

## 1. Approval Procedure

A "Letter of Permission" from Alberta Environment must be obtained by the owner of the sludge-producing facility before sludge can be applied to land. To obtain this approval the form in Appendix III of this document must be completed and delivered to the specified recipient. The applicant may also be requested to provide additional information to that requested on the form. The Director of Standards and Approvals Division or his designated representative will assess the request and, if judged favourable, issue a "Letter of Permission" specifying conditions which must be adhered to in the land application scheme. Assessment of all proposals will be based primarily on the criteria listed in Tables 2 to 6 which are described below.

## 2. Criteria Pertaining to Sludge Classification and Quality

Sludges have been classified into three groups, namely: Digested; Waste-Stabilization Lagoon and Undigested. Digested sludges are potentially less biologically hazardous than those from waste-stabilization lagoons. Undigested sludges pose a greater potential biological hazard than either digested sludges or waste-stabilization lagoon sludges.

Irrespective of class, all sludges must meet the minimum acceptable nitrogen or phosphorus to metal ratios as listed in Table 2. The intention of these criteria is to discriminate against sludges which have high metal contents in combination with either low nitrogen or phosphorus contents. Spiking of sludges with other sources of nitrogen or phosphorus to meet these criteria is not permitted. Sludges which do not meet these criteria can be upgraded by lowering metal inputs to the treatment system or by employing handling and storage techniques which conserve nutrients.

## 3. Criteria Pertaining to Site Classification

Sites proposed for sludge application have been divided into four classes based on: soil pH and texture; slope; and depth to potable aquifers (Table 3). Class 1 sites are the most suitable for sludge application. Class 2 sites are more suitable than Class 3 sites, and Class 4 sites are not acceptable. All sites receiving sludge must have a surface soil pH (determined in $H_2O$) of 6.5 or greater. Proposed sites not meeting this criterion may be upgraded by liming. The minimum pH requirement of 6.5 may be waived if the sludge is derived from a wastewater treatment facility having a lime-based phosphorus removal system. Medium to fine textured soils are preferred, very fine textured soils (HC, C, SiC) are downgraded as they may be more susceptible to runoff problems. The slighter the slope and the greater the depth to a potable aquifer, the more suitable is the site for sludge application.

## 4. Single Application Rates of Sludge and Sludge-Borne Nitrogen

Table 4 lists the amount of sludge and sludge-borne nitrogen which may be applied in a single application for each sludge type and class. Permissible levels of solids and, to a lesser extent, nitrogen decline as site suitability decreases and as the biological hazard of the sludge increases.

## 5. Maximum Cumulative Additions of Sludge-Borne Elements to Soils

These are specified in Table 4. Permissible, cumulative additions decrease as site suitability decreases.

## 6.. Maximum Additions of Sludge-Borne Elements Permitted in One Application

These are one-third of the cumulative additions specified in Table 5.

## 7. Additional Application Restrictions (Table 6)

Minimum distances from a number of environmentally or socially sensitive features are specified in Table 6. Municipalities and haulage contractors are advised that it may often be in their best interests to exceed these buffer distances; they should not be interpreted as maximum distances!

Two methods of application are acceptable. These are:

1. direct injection; and
2. surface application followed, as soon as is feasible, by incorporation (tillage).

Direct injection is preferred and in the future may be deemed by Alberta Environment as the only acceptable method of sludge application. Direct injection of sludge lessens the chance for runoff contamination, reduces the potential for odour and aesthetic problems, and reduces evaporative losses of nutrients, particularly ammonium nitrogen. Assessment of the advantages and disadvantages of injection has, just recently, commenced in Alberta.

Application is restricted to a time of the year when conditions will permit injection or application/tillage. Application to ice-covered, snow-covered or frozen soils is not permitted as subsequent runoff contamination is probable.

Application is restricted to lands intended for the production of forages, oil seeds, small grains, trees and commercial sod. Direct grazing of crops in sludge-treated fields is not recommended for a period of 3 years following application because of concerns related to nitrate content of the crops and transfer of pathogens. The greatest dangers, with respect to excess nitrate content of plants, exist in the first crop immediately following application, in newly-emerging plant tissue and in hail-damaged, immature cereal crops, especially oats. Sludge should not be applied to lands that may be grazed by dairy cattle or used to grow root crops or crops that may be eaten raw.

Provided conditions governing maximum accumulative elemental additions to soils (Table 5) have not been equalled or exceeded, sites previously treated with sludge may be retreated after a period of 3 years has elapsed, if the available nitrogen levels in soil have declined to less than 250 kg/ha computed on the top 150cm depth of soil.

## TABLE 2

Minimum Acceptable Ratios of Nitrogen and Phosphorus to Metals and Boron in Sludge

| | Cd | Cr | Cu | Hg | Ni | Pb | Zn | B |
|---|---|---|---|---|---|---|---|---|
| Nitrogen (Organic + Nitrate + Ammonium) | 1,500 | 20 | 15 | 3,000 | 100 | 20 | 10 | 300 |
| Or[1] | | | | | | | | |
| Phosphorus (Total) | 600 | 8.0 | 6.0 | 1,100 | 40 | 8.0 | 4.0 | 120 |

[1]Sludge is acceptable if either the nitrogen or phosphorus criteria are met. Spiking sludges with nitrogen or phosphorus to achieve these ratios is not permitted.

## TABLE 3

Classfication of Sites on the Basis of Soil Characteristics, Topography and Geology

| | Acceptable[1] | | | Not Acceptable |
|---|---|---|---|---|
| | Class 1 Sites | Class 2 Sites | Class 3 Sites | Class 4 Sites |
| pH | ≥ 6.5 | ≥ 6.5 | ≥ 6.5 | < 6.5[2] |
| "Texture"[3] | CL, SiCL, SiL, Si, SiC L, SCL, SC | C, HC | LS, SL | Sand and gravel[4] |
| Slope[5] % | 0-2 | 2-5 | 5-9 | 9 |
| Depth to Potable Aquifer (m) | >5 | 3-5 | 2-3 | < 2 |

[1] A site falls into the lowest class represented by any characteristic.

[2] A site with a pH less than 6.5, which would otherwise be classed 1 or 2 may be upgraded by liming to pH 6.5 or higher.

[3] As determined on samples from representative soil horizons to a depth of at least 30 cm.

[4] Other class 4 sites include stream valleys, intermittent drainage areas and organic soils.

[5] Restriction of sludge application rates based on slope considerations apply only when surface application methods are employed. Slope criteria can be relaxed if sludge is applied by subsurface injection.

## TABLE 4

Maximum Addition of Sludge Solids and Sludge-Borne Nitrogen for Each Site Class and Sludge Type - Single Application

| Sludge Type | Solids Applications Rate[1] t/ha-dry weight basis | | | Total Nitrogen Application Rate kg/ha | | | Available Nitrogen [$(NH_4 + NO_3)$ as N] Application Rate For Surface Spreading[2] kg/ha | | |
|---|---|---|---|---|---|---|---|---|---|
| | Class 1 Sites | Class 2 Sites | Class 3 Sites | Class 1 Sites | Class 2 Sites | Class 3 Sites | Class 1 Sites | Class 2 Sites | Class 3 Sites |
| Digested | 25 | 20 | 10 | 900 | 700 | 400 | 450 | 350 | 200 |
| Waste Stabilization Pond | 10 | 8 | 5 | 800 | 600 | 300 | 400 | 300 | 150 |
| Undigested[3] | 5 | 4 | 2.5 | 600 | 500 | 200 | 300 | 250 | 100 |

1. For surface application a maximum hydraulic loading rate of 100 $m^3$/ha/day is imposed for sludges containing less than 5% solids. Allowable solids and nitrogen rates for such sludges may be achieved by making several incremental additions with the soil cultivated between each addition. There is no hydraulic loading rate restriction on sub-surface injection.

2. For sub-surface injection the maximum available nitrogen application rate is 200 kg/ha on Class 1 and 2 Sites and 150 kg/ha on Class 3 Sites.

3. Undigested sludge must have been stored for a minimum of 6 months, have a pH of greater than 12 or have a volatile solids content of less than 60% of the total weight of solids.

## TABLE 5

single application 1/3 of below

Maximum Cumulative Additions of Sludge-Borne Elements to Soils* (kg/ha)

| | B** | Cd | Cr | Cu | Hg | Ni | Pb | Zn |
|---|---|---|---|---|---|---|---|---|
| Class 1 Sites | 10 | 1.5 | 100 | 200 | 0.5 | 25 | 100 | 300 |
| Class 2 Sites | 7.5 | 1.1 | 75 | 150 | 0.4 | 19 | 75 | 200 |
| Class 3 Sites | 5 | 0.8 | 50 | 100 | 0.2 | 12 | 50 | 150 |

* Not more than one-third of the cumulative loading may be applied in a single application.

** Boron levels are hot-water soluble. Levels for other elements are based on total quantities.

## TABLE 6

Additional Application Restrictions

1. **Method of Application**

**Acceptable** methods include INJECTION and SURFACE APPLICATION. If surface application is employed it must be followed, as soon as is possible, by tillage.

2. **Minimum Acceptable Distances From Specified Features[1]**

The following minimum distances are required: It may often be in the interest of the municipality and haulage contractor to exceed these to ensure public acceptance of sludge spreading programs.

| FEATURE | MINIMUM DISTANCE m | PREFERRED DISTANCE m |
|---|---|---|
| Rivers[2], Canals[2], Creeks[2], Intermittent Drainage Courses, Lakes, Sloughs, Dugouts | 30* | 50 |
| Water Wells | 20 | 50 |
| Areas Zoned Residential or Devoted to Urban Use | 500* | 800 |
| Occupied Dwellings | 60* | 100 |
| Road Allowances | 10 | 20 |
| Public Building Perimeters | 10 | 30 |
| Public Buildings | 60* | 100 |
| School Yard Boundaries (School in Session) | 200* | 500 |
| School Yard Boundaries (School not in Session) | 20* | 20 |
| Cemeteries, Playgrounds, Parks, Campgrounds | 200* | 500 |

[1] Greater separation distances may be required based on local topographic and climatic conditions.

[2] Distances required are from the major break in slope.

* Distances can be reduced by 67% if sludge is sub-surface injected.

## TABLE 6 (continued)

3. **Seasonal**

APPLICATION is permitted during spring, summer and fall and is not permitted on ground which is ice-covered, snow-covered or frozen.

4. **Land Use**

| **Acceptable Crops**[1] | **Unacceptable** |
|---|---|
| Forages[2] | Root Crops |
| Oil Seed Crops | Vegetable & Fruit |
| Small Grains[3] | Crops |
| Commercial Sod | Tobacco Crops |
| Trees | Dairy Pasture Land |

[1] Permission to apply sludge on lands intended for growth of crops not listed may be given.

[2] Direct grazing of sludge treated forage lands is not recommended for a period of 3 years immediately following application.

[3] Wheat is preferable to barley. Oats are not recommended in the first two growing seasons following sludge treatment.

5. **Application of Sludge to a Previously Treated Site**

In addition to criteria listed in Table 4, three conditions must be met before re-application of sludge to a particular site is premitted. These are:

(1) A minimum period of 3 years must have elapsed;

(2) The available nitrogen ($NH_4$ & $NO_3$) levels in the soil must be less than 250 kg/ha as computed on the surface, 0-150 cm depth; and

(3) The maximum additions of sludge-borne elements do not exceed the limits specified in Table 5.

## FINANCIAL ASSISTANCE

Capital costs associated with sludge disposal facilities and equipment are considered part of the total sewage treatment plant costs and as such are eligible for Provincial financial assistance under the Alberta Municipal Water Supply and Sewerage Treatment Grant Program. Sludge pumping and loading facilities as well as sludge hauling and application equipment are considered eligible cost items.

Municipalities should incorporate sludge disposal facilities and equipment into planned sewage treatment plant upgradings to realize full benefit of the financial assistance available. The purchase of sludge hauling and application equipment may not be justified for a small community, however, co-operative use of purchased equipment with other communities in the area may make such purchases cost-effective.

Further information on the financial assistance available for sludge disposal facilities and equipment may be obtained by contacting:

Alberta Environment
Standards and Approvals Division
Municipal Engineering Branch
5th Floor, 9820 - 106 Street
Edmonton, Alberta
T5K 2J6
(Telephone: (403) 427-5877)

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# APPENDIX I

Estimated Existing and Projected Annual Sewage Sludge Production Quantities for Selected Municipalities in Alberta

| Municipality | 1980 Pop. | 1980 Sludge Production (dry tonnes) | 1990 Pop. | 1990 Sludge Production (dry tonnes) |
|---|---|---|---|---|
| Calgary[1] | 550,000 | 13,000 | 765,000 | 24,000* |
| Edmonton[2] | 480,000 | 15,000 | 640,000 | 22,000 (28,150)* |
| Lethbridge | 55,000 | 1,800 | 69,000 | 2,300 (2,850)* |
| Red Deer | 43,000 | 1,540 | 73,000 | 2,420 (3,050)* |
| Medicine Hat[3] | 43,000 | — | 53,000 | 2,150 (2,700)* |
| Edmonton Regional Sewage Plant[4] | — | — | 181,500 | 7,500* |

[1] Includes Airdrie

[2] Excludes 25,000 people served by Cloverbar Lagoons

[3] Includes Redcliff

[4] Will serve Beaumont, Ft. Saskatchewan, Gibbons, Leduc, Morinville, Sherwood Park, Spruce Grove, St. Albert & Stony Plain.

* Sludge production assuming Alum addition to wastewater for phosphorus removal to 1 mg/L Total – P.

## APPENDIX II

CHEMICAL COMPOSITION OF ALBERTA SEWAGE SLUDGE AS % OF DRY WEIGHT

| Municipality | Solids | TKN | $NH_4 - N$ | P-total | Ca | Mg | Na | K | Fe |
|---|---|---|---|---|---|---|---|---|---|
| Bentley | 9.7 | 1.78 | 0.28 | 0.38 | 1.23 | 0.60 | 0.024 | 0.39 | 2.44 |
| Blairmore | 11.4 | 4.10 | 0.560 | 0.571 | 2.29 | 0.370 | 0.0575 | 0.314 | 0.925 |
| | 6.05 | 3.77 | 0.667 | 0.809 | 4.32 | 0.399 | 0.0383 | 0.326 | 0.611 |
| | 0.80 | 6.58 | 4.10 | 2.06 | 3.39 | 0.787 | 0.306 | 1.09 | 0.976 |
| Brooks | 10.76 | 5.07 | 1.83 | 1.82 | 4.79 | 0.942 | 0.036 | 0.26 | 1.217 |
| Calgary | 11.5 | 4.66 | 1.54 | 1.75 | | | | | 1.03 |
| | 11.6 | 4.60 | 1.43 | | | | | | 1.23 |
| | 12.4 | | 1.47 | | | | | | 1.30 |
| | | | | 1.41 | 4.21 | 0.800 | 0.0300 | 0.260 | 1.60 |
| | 13.3 | 4.45 | 1.16 | 1.78 | 4.49 | 0.980 | 0.100 | 0.245 | 1.18 |
| Coaldale | 12.8 | 1.75 | 0.175 | 0.510 | 2.24 | 0.745 | 0.369 | 0.593 | 1.72 |
| | 1.68 | 1.94 | 0.509 | 0.500 | 1.89 | 0.584 | 0.147 | 0.405 | 1.50 |
| | 3.93 | 2.12 | 0.264 | 0.486 | 1.87 | 0.589 | 0.0726 | 0.504 | 1.58 |
| | 15.6 | 1.78 | 0.160 | 0.465 | 1.80 | 0.547 | 0.0623 | 0.455 | 1.57 |
| | 14.7 | 1.81 | 0.350 | 0.460 | 1.92 | 0.565 | 0.0636 | 0.439 | 1.33 |
| Coleman | 2.3 | 5.88 | 2.03 | 1.59 | 2.11 | 0.378 | 0.214 | 0.444 | 1.48 |
| | 1.04 | 6.47 | 0.470 | 1.72 | 2.74 | 0.504 | 0.373 | 0.568 | 1.62 |
| Devon | 14.5 | 1.76 | 0.0268 | 0.474 | 3.66 | 0.750 | 0.599 | 0.511 | 2.02 |
| Drumheller | 1.2 | 4.81 | | 1.34 | 1.47 | 0.702 | 0.645 | 0.604 | 1.32 |
| Edmonton | 10.5 | 3.72 | 1.50 | 1.81 | 6.10 | 0.720 | 0.114 | 0.360 | 1.70 |
| | 10.3 | 3.82 | 1.59 | | | | | | |
| | 12.5 | 3.92 | 1.45 | 1.43 | 4.84 | 0.760 | 0.100 | 0.330 | 2.03 |
| | 11.7 | 3.55 | 1.10 | 1.59 | 5.55 | 0.758 | 0.123 | 0.353 | 2.05 |
| Elkpoint | 17.8 | 2.32 | 0.265 | 0.250 | 1.28 | 0.374 | 0.0886 | 0.170 | 1.15 |
| Fort Macleod | 1.7 | 4.90 | 1.05 | 1.14 | 3.12 | 0.731 | 0.295 | 0.547 | 1.36 |

## APPENDIX II (continued)

| Municipality | Solids | TKN | $NH_4 - N$ | P-total | Ca | Mg | Na | K | Fe |
|---|---|---|---|---|---|---|---|---|---|
| Innisfail | 5.18 | 2.12 | 0.44 | 0.470 | 2.34 | 0.580 | 0.360 | 0.320 | 1.12 |
| | 4.8 | 3.38 | 0.77 | 0.746 | 3.66 | 0.750 | 0.599 | 0.511 | 2.02 |
| Lethbridge | 19.1 | 2.44 | 0.0826 | 0.590 | 2.50 | 0.760 | 0.0690 | 0.226 | 1.57 |
| | 3.8 | 3.20 | 1.03 | 1.82 | 6.59 | 1.68 | 0.590 | 0.160 | 0.582 |
| | 1.6 | 8.92 | 4.52 | 2.12 | 3.88 | 1.01 | 3.12 | 0.650 | 1.20 |
| | 1.53 | 10.70 | 5.69 | 2.32 | 3.99 | 0.890 | 3.37 | 0.738 | 0.850 |
| | 1.81 | 8.72 | 4.89 | 2.21 | 3.99 | 0.860 | 2.89 | 0.651 | 0.900 |
| Nanton | 2.6 | 4.00 | 2.10 | 1.31 | 2.92 | 0.705 | 0.535 | 0.360 | 0.858 |
| Okotoks | 18.2 | 3.57 | 0.33 | 1.10 | 4.32 | 0.79 | 0.06 | 0.37 | 1.21 |
| Olds | 5.8 | 3.24 | 0.900 | 0.740 | 2.42 | 0.470 | 0.520 | 0.380 | 0.980 |
| Red Deer | 11.2 | 4.12 | 1.11 | 1.63 | 4.62 | 1.21 | 0.164 | 0.529 | 0.177 |
| Sunshine Village | 5.65 | 6.68 | 1.45 | 1.60 | 2.34 | 0.660 | 0.110 | 0.372 | 0.502 |

CHEMICAL COMPOSITION OF ALBERTA SEWAGE SLUDGE
AS mg/kg DRY SLUDGE

| Municipality | Mn | Zn | Cu | Pb | Ni | Cd | Cr | B | Hg |
|---|---|---|---|---|---|---|---|---|---|
| Bentley | 193 | 594 | 550 | 358 | 40 | 5.5 | 33 | | |
| Blairmore | 141 | 334 | 372 | 130 | 45 | 5 | | | |
| | 117 | 389 | 500 | 67 | 50 | 5 | 64 | 33 | |
| | 142 | 444 | 532 | 133 | 35 | 5 | 70 | | |
| Brooks | 173 | 1147 | 812 | 1048 | 52 | 13 | 519 | | |
| Calgary | | 1250 | 780 | 1570 | 16.1 | 8.7 | 396 | 15.5 | |
| | | 1100 | 674 | 1470 | 32.2 | 10.7 | 382 | 11.2 | |
| | | 1060 | 730 | 1680 | 34.6 | 10.5 | 390 | | |
| | 320 | 1400 | 700 | 680 | 64 | 9.3 | 550 | | 2 |
| | 180 | 1090 | 710 | 860 | 54 | 12 | 480 | | |

## APPENDIX II (continued)

| Municipality | Mn | Zn | Cu | Pb | Ni | Cd | Cr | B | Hg |
|---|---|---|---|---|---|---|---|---|---|
| Coaldale | 149 | 595 | 1011 | 166 | 36 | 6 | 65 | | |
| | 112 | 587 | 1015 | 139 | 32 | 5 | 56 | | |
| | 132 | 579 | 947 | 179 | 32 | 5 | 68 | 17.5 | |
| | 119 | 596 | 975 | 179 | 38 | 5 | 81 | | |
| | 122 | 663 | 995 | 205 | 44 | 6 | 95 | | |
| Coleman | 90 | 370 | 420 | 51 | 16 | 4 | 22 | | 1 |
| | 81 | 541 | 541 | 108 | 18 | 5 | 75 | | |
| Devon | 319 | 569 | 957 | 80 | 37 | 5 | 159 | 10.5 | |
| Drumheller | 330 | 391 | 275 | 116 | 39 | 6 | 110 | | |
| Edmonton | 380 | 800 | 420 | 510 | 93 | 15.3 | 1660 | | 3.1 |
| | 360 | 850 | 420 | 330 | 96 | 14 | 1700 | 9 | 2 |
| | 382 | 561 | 346 | 190 | 103 | 12 | 1532 | | |
| Elkpoint | 963 | 402 | 792 | 88 | 47 | 4 | 71 | 6.5 | |
| Fort Macleod | 160 | 510 | 650 | 130 | 31 | 7 | 48 | 9.5 | 1 |
| Innisfail | 235 | 375 | 450 | 69 | 48 | 4 | 49 | 10.5 | |
| | 319 | 569 | 957 | 80 | 37 | 5 | 159 | | |
| Lethbridge | 201 | 311 | 215 | 131 | 21 | 8 | | | 6 |
| | 160 | 610 | 340 | 130 | 31 | 6 | 180 | | 4 |
| | 220 | 615 | 310 | 120 | 53 | 5 | 160 | | 1 |
| | 160 | 510 | 260 | 190 | 35 | 6 | 180 | | |
| | 160 | 400 | 230 | 160 | 45 | 6 | 190 | | |
| Nanton | 224 | 703 | 536 | 158 | 16 | 6 | | | 2 |
| Okotoks | 225 | 693 | 1300 | 137 | 19 | 6 | | | |
| Olds | 150 | 550 | 615 | 220 | 15 | 6 | | 9 | 1 |
| Red Deer | 340 | 680 | 160 | 98 | 42 | 6 | 69 | | |
| Sunshine Village | 140 | 870 | 520 | 73 | 40 | 7 | 60 | | |

## APPENDIX III

### APPLICATION FOR PERMISSION TO APPLY SLUDGE TO LAND IN ALBERTA

Pursuant to Section 11 of the Alberta Clean Water (General) Regulations, OC 216/73, written permission for land application of sludge is required from the Director of Standards and Approvals Division. Application for a "Letter of Permission" must be made to the Director of Standards and Approvals by the owner of the facility producing the sludge or his/her authorized agent. Completion of this form constitutes such an application. Completed forms accompanied by a map delineating the proposed disposal site should be sent to:

Director, Standards and Approvals Division
c/o Municipal Engineering Branch
Alberta Environment
5th Floor, Oxbridge Place
9820 - 106 Street
Edmonton, Alberta T5K 2J6

Name, address and phone number of Municipality

_____

_____

Sludge Type _____ Digested _____ Anaerobic _____ Aerobic

_____ Waste stabilization lagoon

_____ Undigested

Sludge solids content _____ percent

Volume of Sludge proposed for land application _____ cubic meters

Location of proposed application site

_____ Section _____ Township _____ Range _____ W _____ Meridian

Has sludge been applied to this site previously

_____ Yes. Specify dates _____ _____ No

Proposed method of application

_____ Injection _____ Surface application and incorporation

Name, address and phone number of the haulage contractor

_____

_____

(continued)

## APPENDIX III (continued)

Does the proposed site meet all distance criteria in Table 6 of this document?

_____ Yes _____ No

If no, specify which criteria are not met and by what distance

_____

_____

Current use of the proposed site

_____ Fallow _____ Cropped. Specify _____

Intended use of the proposed site in the next growing season

_____ Fallow _____ Crop. Specify _____

Name, address and phone number of the land owner

_____

_____

Proposed date of commencement _____

Proposed date of termination _____

Signature of Mayor or authorized agent _____

Date _____

Signature of land owner _____

Date _____